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(54) Process for the catalytic steam reforming of a hydrocarbon feedstock

(57) Process for the catalytic steam reforming of a hydrocarbon feedstock including the steps of pre-reforming a hydrocarbon steam mixture in contact with a first steam reforming catalyst being arranged in an externally heated pre-reformer in a flue gas channel from a fired steam reformer, and contacting pre-reformed effluent from the pre-reformer with a second steam reforming catalyst in a fired steam reformer, which process includes the further step of contacting the pre-reformed effluent with a third steam reforming catalyst being arranged outside the flue gas channel upstream the externally heated steam reformer.

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Description

[0001] The present invention relates to a process for the catalytic steam reforming of a hydrocarbon feedstock. In particular, the invention provides an improved process of the above type including the steps of pre-reforming a hydrocarbon steam mixture in contact with catalysed hardware having activity in steam reforming and being arranged on wall of an externally heated pre-reformer, and, subsequently, contacting pre-reformed effluent from the pre-reformer with a steam reforming catalyst arranged catalysed hardware monolith in a fired steam reformer.

[0002] Pre-reforming of a hydrocarbon feedstock in the preparation of synthesis gas is well known in the art. Pre-reforming is generally employed with hydrocarbon feed containing higher hydrocarbons or for increasing the capacity of existing reformer plants. Process gas of the hydrocarbon feedstock and steam is thereby introduced in a pre-reformer at temperatures of about 450°C to 550°C. By the steam reforming reactions proceeding in the pre-reformer, the temperature in the process gas usually decreases when carrying out the pre-reforming process in adiabatic manner.

[0003] In industrial synthesis gas preparation plants the pre-reformed process gas is subsequently reheated to the required inlet temperature to the fired steam reformer by heat exchange with hot flue gas from the fired reformer. The usual inlet temperature into an industrial reformer is between 600°C and 700°C.

[0004] Improved utilisation of heat in the hot flue gas from the fired steam reformer is disclosed in EP Patent Publication No. 855,366. In the process of the latter patent publication process gas to the steam reformer is partly reformed in a pre-heater coil provided with a thin film of steam reforming catalyst on wall of the coil. A high amount of valuable heat in the flue gas is then transferred to and absorbed by the process gas through endothermic steam reforming reactions proceeding on the wall-coated catalyst. The coil dimension and amount of catalyst is thereby adjusted to increase the exit temperature in partially reformed process gas from the catalysed pre-heater coil to the required temperature at inlet to the fired steam reformer.

[0005] The main disadvantage of the latter process is decreasing catalyst activity at long time operation of the catalysed pre-heater coil resulting in a coil exit temperature above the maximum allowable gas temperature at inlet of the fired steam reformer due to decreased heat absorption at diminished steam reforming in the gas. The catalyst has then to be reactivated or replaced with fresh catalyst on the coil wall. Replacement of catalyst in the pre-heater coil is a difficult and expensive operation when demounting of the coil from the flue gas channel.

[0006] The general object of this invention is to improve long term operability of a steam reforming process of the above type by compensating a decreasing catalyst activity in the pre-heater coil by means of an additional catalyst unit being easy to replace.

[0007] In accordance with the above object, this invention provides a process for the catalytic steam reforming of a hydrocarbon feedstock including the steps of pre-reforming a hydrocarbon steam mixture in contact with a first steam reforming catalyst being arranged in an externally heated pre-reformer in a flue gas channel from a fired steam reformer and contacting pre-reformed effluent from the pre-reformer with a second steam reforming catalyst in a fired steam reformer, which process includes the further step of contacting the pre-reformed effluent with a third steam reforming catalyst being arranged outside the flue gas channel upstream the externally heated steam reformer.

[0008] By the inventive process loss of activity in the pre-reformer unit during long time operation will be compensated by steam reforming reactions in pre-reformed effluent within an intermediate reforming unit being arranged between outlet of the pre-reformer in the flue gas channel and inlet of the fired steam reformer. The intermediate unit will then be operated at substantially adiabatic conditions and compensate decreasing steam reforming activity of the steam reforming catalyst or catalysed hardware in the heated pre-reformer and the resulting temperature increase in the effluent from the pre-reformer.

[0009] Beside of providing the required temperature adjustment of the process gas below the maximum inlet temperature into the fired steam reformer at long term operation, a further advantage of the intermediate reformer unit is the siting of the unit outside the flue gas channel. To compensate decreasing activity in the pre-reformer as described above, it will be necessary to replace or reactivate spent catalyst upstream the fired steam reformer. As mentioned herein before replacement of spent catalyst in a unit within the flue gas channel is time consuming and expensive to handle.

[0010] By arranging an intermediate catalyst unit outside the flue gas channel according to the invention, spent catalyst is then replaced in the intermediate reformer unit and the replacement operation simplified considerably.

[0011] The intermediate catalyst unit is thereby preferably mounted in a pipe connecting the pre-reformer with the fired steam reformer outside the flue gas channel. The catalyst in the intermediate unit may be of any shape conveniently employed in steam reforming of hydrocarbons. To reduce pressure drop in the unit, the catalyst is preferably shaped as straight channel monolith.

[0012] Size and activity of the catalyst in the intermediate catalyst unit depend on the actual process lay-out.

Claims

1. Process for the catalytic steam reforming of a

hydrocarbon feedstock including the steps of pre-reforming a hydrocarbon steam mixture in contact with a first steam reforming catalyst being arranged in an externally heated pre-reformer in a flue gas channel from a fired steam reformer, and contacting pre-reformed effluent from the pre-reformer with a second steam reforming catalyst in a fired steam reformer, which process includes the further step of contacting the pre-reformed effluent with a third steam reforming catalyst being arranged outside the flue gas channel upstream the externally heated steam reformer.

2. Process of claim 1, wherein the first steam reforming catalyst is a thin film catalyst arranged on wall of the externally heated pre-reformer.

3. Process of claim 1, wherein the third steam reforming catalyst is a monolithic structured catalyst.